Eco-innovation indicators

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Executive summary

Appropriate indicators should be developed in order to better analyse the development of eco-innovation including evolution of environmental technologies' markets. They should also measure the progress made in implementing the Environment Technology Action Plan.

Currently, the field of eco-innovation lacks statistics and indicators. The challenge consists very much of trying to combine the two important frames in eco-innovation development: the innovation chain or system; and environment technology seen in a wider perspective. However, the methods and perspectives applied in innovation indicators are quite different from environmental indicators. Eco-innovation indicators are response-indicators measuring societal progress, supplementing other indicators along the DPSIR chain (**D**riving forces, **P**ressures, **S**tate, **I**mpact and **R**esponse). Also, eco-innovation indicator development is at an early stage, which means the development must be underpinned by research, conceptual development, surveys and assessments.

The report discuss key questions like: what kind of indicators do we need, the availability of existing data sources and methods of measuring eco-innovation using patent and R&D statistics; and studies on the environmental industry and their environmental performance. These data sources have so far only to a small extent been applied to eco-innovation analyses.

Existing data at Eurostat and eco-innovation statistics within composite indicators at Joint Research Centre – Institute for the Protection and Security of the Citizen are described.

1. Background

In recent years there is still more emphasis on the linkages between environmental and innovation policy. With the "Lisbon process" a new era of environmental policy began where environmental protection systems alone are seen as insufficient for handling an increasingly complex set of challenges.

With the recently launched European Environmental Technologies Action Plan (ETAP) new policy signals were sent in the simultaneous pursuit of environmental and competitiveness goals (COM(2004) 38). For the first time environmental and innovation policies were sought aligned. However, the ETAP need as yet to be unfolded. Indicators could play an important role in operationalizing targets and creating stronger political rigour.

Following up on the ETAP the Informal Environment Council held in July 2004 created a renewed political interest in pursuing eco-innovations as an opportunity (Kemp and Andersen, 2004; Kemp, Andersen and Butter, 2004). This meeting pointed to the development of demonstration and indicators as important means for creating incentives for eco-innovation (Kemp and Andersen, 2004).

The report on the implementation of ETAP adopted by the Commission in January 2005 (COM(2005) 16 final), calls for the development of indicators on eco-efficiency and on the market penetration of environmental technologies. An extract of the report conclusions is the following:

"*Appropriate indicators should be developed in order to better analyse the development of eco-innovation and evolution of environmental technologies' markets. They should measure both market developments and the performance of EU industry in the market. They should also measure the progress made in implementing the Action Plan as well as the eco-efficiency of the EU economy. They should build on the work done by the Commission (Eurostat) in the field of environmental accounting and of eco-efficiency indicators*."

The EEA has a special focus on monitoring, assessment and reporting. Contributing to the development of eco-innovation indicators could be an important way for EEA to support the ETAP. The EEA has therefore taken the initiative to produce this scoping study on the prospects of developing eco-innovation indicators. The report should function as a starting platform for in depth work on developing ETAP indicators, as well as providing inputs for future EEA Signals Report.

Currently, the field of eco-innovation lacks statistics and indicators. The challenge consists very much of trying to align two well-developed but different set of indicator bodies, the environmental and the innovation set. However, the methods and perspectives applied in innovation indicators are quite different from environmental indicators, as we shall return to, reflecting the different rationales of respectively innovation policy and environmental policy (Andersen, 2004, Kemp and Andersen, 2004). There is, consequently, a considerable need for conceptual as well as methodological clarifications in order to develop eco-innovation indicators.

There are several key issues to address in this study:

- What kind of indicators do we need? This entails setting up a frame for eco-innovation indicators, defining and clarifying precisely how we understand eco-innovation and what perspective to apply – products, systems or services – and discuss their different explanatory values and policy implications.

- How to evaluate the availability an adequacy of existing data sources and methods of measuring eco-innovation? Focus is here on the three main methods: the environmental industry statistics, eco-efficiency and sectoral analysis.

- Investigating into new possible inquiries from hard core innovation data sources. Such as looking at patents, R&D analysis, and surveys. As well as discussing more overall but important themes such as market penetration and globalisation.

- Discussing briefly the subject approach, i.e. the greening of core actors in the innovation system and the dynamics of the innovation system as a whole.

- Conclusion and policy implications. Findings on the analytical frame and data accessibility are discussed and key challenges are identified, including a tentative characterization of the low, medium and high "hanging fruits". Policy implications are discussed.

- Considering the early stage in the development of eco-innovation indicators (*"EI-indicators"*) A key aim should therefore be to agree on a frame, identify the "low hanging fruits", which could allow early indicator work to take form, but also to draw up the perspectives and needs for more long-term, ambitious indicator work.

This short paper provides background information for the next steps. It seeks to draw up key issues to consider as well as present a dense overview on relevant central existing and upcoming data sources and methods.

In section 2 key issues and challenges are developed. In section 3 an appropriate analytical frame is discussed. In section 4, the existing and new data sources and methods are run through, adding a few questions to each. In appendix 1 possible statistical contributions from Eurostat are summarized, and JRC has in appendix 2 summarized possible relevant inputs from composite indicators.

2. Key considerations in developing eco-innovation indicators

Generally we are far from EI-indicators and the methodological problems and uncertainties are considerable. It is important not to let these problems guide the indicator work too much but rather to take a starting point in what indicators we want and what steps to take to get these (i.e. not only go for the low hanging fruits).

The EI indicators should serve 3 purposes:

a) EI-indicators potentially possess a powerful novel signal effect, placing new focus on the eco-innovation development rather than the environmental state. Indicators which allow for international benchmarking at the national and regional level are important for the political signalling. The signalling effect is strengthened if EI-indicators are integrated into innovation statistics and indicator work

b) EI- indicators should be developed so they provide maximum incentives for environmental action among key actors in the innovation system.

c). EI-indicators can provide new analytical insights into the greening of industry and the economy, So far quantitative empirical analysis of eco-innovation is very limited.

The innovation indicator frame(s) are well-developed for example by the European Innovation Scoreboard (EIS) and should form the basis for EI indicators – need to be adapted to environmental data and policy agendas.

Defining and operationalizing eco-innovation is the key problem. Sharp definitions and classifications are lacking and system perspectives are neglected. We do not only need typologies but explanations of eco-innovations in innovation terms.

The innovation chain and innovation system perspective need to be combined.

Sector specific analyses are central to allow for internationally comparative analyses and structural conditions.

Globalisation and the resulting changes in the international division of eco-innovative labour is a rising challenge that is poorly analyzed and need to be addressed.

EII indicators need to be aligned with the Corporate Social Responsibility (CSR) agenda.

There are quite some data sources available for making EI-indicators, though long time series are often lacking. The challenge consists in many cases in combining existing data in new ways and/or reinterpreting these in innovation terms. There is hence a need to look thoroughly into their explanatory values.

But there is also a need for developing new data sources and/or strengthening existing ones, in order to pursuit new types of inquiries. Interesting work is under way.

Development of composite indicators for eco-innovation should be considered in order to supplement the wider and in some aspects more narrow innovation indicators.

3. Eco-innovation indicators – setting up a frame

Eco-innovation indicators are response indicators, which measure societal developments in eco-innovation on different levels). They differ fundamentally from traditional environmental indicators, which focus on measuring the state of the environment (the air, soil and water), and eco-efficiency indicators located earlier in the DPSIR chain. (See below).

Innovation indicators seek to measure the innovative capacity of agents. The agent can be a country, a region (e.g. EU), a sector or a company. Either by measuring the *innovation output* (rate of new products on the market, knowledge intensity of products, degree of patents, market share etc.), or the innovation input, noticeably the *competence level*, (e.g. investments in research and education, degree of citations, knowledge flows and clusters etc.) which provide the basis for carrying out innovation.

It is not easy to measure innovation, since a lot of the available data are closely related to formal research activities, but much innovation builds on other forms of knowledge creation or is less high tech. Typically, therefore, different indicators, often composite indicators, are used to provide a more comprehensive picture of the innovative capacity of a given agent.

It is even more difficult to measure eco-innovation, since it is difficult to define. A stringent definition and delimitation of different forms of eco-innovation/environmental technologies is a necessary starting point for developing indicators and this is not in place. The level and structure of analysis, what to be included and what not are important issues and different institutions apply different definitions.

Eco-innovations/environmental technologies have been defined with very different purposes, e.g. as an object for environmental regulation or administration or as an industrial growth area, often with somewhat unclear definitions. The concept of environmental technologies has changed in time with the changing environmental agenda. End-of-pipe-technology, best available technology, cleaner production and industrial ecology are only a few concepts illustrating the environment technology agenda over time. With a still more preventive approach to environmental issues innovation and eco-innovation is becoming still more entangled, none the least for the companies. Sharp, consolidated and operational definitions are lacking. In order to utilize statistical information on eco-innovation we need a more stringent taxonomy of eco-innovations. On the other hand a pragmatically approach is necessary. The development of best needed indicators must not be an obstacle for use of best available indicators.

Environmental innovation research is still in its early phase, and there are worldwide very few actual innovation researchers working with environmental issues. The research is severely prohibited by the difficult data access. Therefore little work has been done on developing these indicators and the time is ripe for setting new standards in this area.

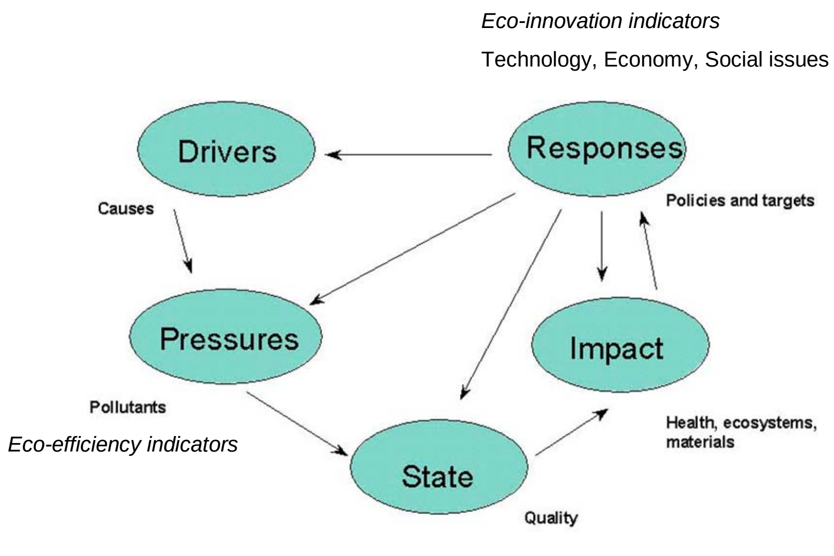

Figure 1: Eco-innovation can be described as response indicators using the EEA DPSIR framework (Driving forces, Pressures, State, Impact and Responses)

3.1 Setting up a frame

It is essential that a stringent frame is set up which will allow us to identify a coherent set of parameters which address key issues of eco-innovation.

Two different (but supplementary) approaches will be discussed. Studies of innovation take either an “object approach” or a “subject approach”. The Oslo manual states that the object approach concentrates on the characteristics of individual innovations while the subject approach focuses on the innovative behavior and activities of the enterprise as a whole (OECD and Eurostat, 1997). With the rise of the innovation system perspective, now forming the basis of much innovation analysis and innovation policy, the subject approach has become much broader focusing on the key knowledge producers (the “innovation dynamo”: companies and knowledge institutions) and the surrounding institutional set up.

The question is in other words whether we should focus on a greening of the innovation chain or a greening of the innovation system, or if these analyses or perspectives should be combined in the chosen frame? It is suggested here that an EI frame should build on combining 3 elements: 1) the innovation chain, 2) the innovation system and 3) a taxonomy of eco-innovations.

Element 1. Innovation objects - the chain: innovative activities from idea generation to value creation):

Innovation is commonly defined as novelty leading to value creation on the market. The Draft Innovation Action Plan of the Commission defines innovation as the commercial application of existing knowledge in a new context. Hence the innovation concept covers the whole sequence from idea to commercialization on the market and should be seen as closely related to competitiveness.

The linear model of innovation which sees the innovation process as a one-stringed sequence springing from R&D is nowadays superseded by a chain-linked model representing a much more complex perspective on innovation.

1.Idea formulation (expectations on potential market)	**2.Invention** (analytic design, demonstration)	**3.Technology development** (early stage with detailed design and tests)	**4.Production** (further development, up-scaling)	**5.Marketing** (value creation on the market, diffusion)

Figure 2. Stages in the chain linked model of innovation Source: modified from Kline and Rosenberg (1986).

The sequences are strongly linked and increasingly so. During each “stage” ideas get formulated and reformulated. The innovation system research underlines, how the organization of knowledge production is undergoing change in the knowledge economy. The rising pace of innovation means that the innovation process becomes still more complex. In the attempt to reach the market first with the new products, there is an increasing use of multiple knowledge sources, feedback and parallel sequences in the stages of the innovation process (OECD 2000). The term open innovation is often used to describe this more complex non-linear process.

Eco-innovation indicators should cover innovation activities in the entire chain, i.e.

- Competence (investments in research and development, skills and education, organisational development)
- Innovation output (eco-efficiency & sector analysis, patents, LBIO)
- Market penetration (market shares, trade)

Risk: The object perspective is easily reduced to a simple linear approach to innovation, and it needs therefore to be combined with the subject approach. Also, there is risk of confusion in mixing up the life cycle of the single innovation with the life cycle of markets/technologies.

The innovation concept is not static. The European Commission points to the changing competitive conditions of the knowledge economy arguing for the need to take on a broader innovation concept in their communication to the Council[1] on the union's future approach to innovation policy. In the forthcoming Oslo Manual (in print) the following four types of innovation are pointed to:

1. *Product innovation,*
2. *Process innovation*
3. *Organisational innovation* or business model innovation, related to innovative ways of organising work in areas such as workforce management, distribution, finance and manufacturing.
4. *Marketing innovation,* covering innovations in design and marketing.

It is important that EI indicators take on a comprehensive perspective on innovation.

Element 2. Innovation subjects: The greening of actors/institutions in the innovation system:

The national innovation system perspective, which dominates much RTD policy making, emphasizes how knowledge generation is an interactive process between many actors springing from multiple sources (Lundvall, 1988, 1992, OECD 2000). The national and regional innovation system analyses seek to identify the central knowledge producers and the patterns of their interaction, together with identifying the central framework conditions for the innovation process. The purpose is not only to shed light on the many elements that influence the innovation process but to focus on the interplay, the synergies and the match and mismatch between the different elements[2]. From an innovation system perspective then the focus is very much on making the sub-elements of the system work effectively together as a whole, to achieve an overall high national or regional innovative capacity.

Key elements for developing eco-innovation indicators are:

- Organisational development (companies): CSR/EMS data, environmental accounting/triple bottom line.
- Eco-Entrepreneurship: the role of green upstarts for eco-innovation.
- The financial sector.
- Knowledge institutions and education.
- Knowledge flows (input-output analysis, trade statistics, labour mobility, surveys/patent and text/bibliometric analysis on collaboration and knowledge sources)
- Governance and institutional set up: degree of innovation friendly environmental policy styles.

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[1] Innovation policy: updating the Union's approach in the context of the Lisbon strategy, Communication from the Commission COM (2003) 112 final - 11.3.2003

[2] The European Commission states in their communication on innovation policy, that the innovation system perspective entails a shift in policy rationale in research and innovation policy from"*simply addressing market failures that lead to underinvestment in R&D towards one which focuses on ensuring the agents and links in the innovation system work effectively as a whole, and removing blockages in the innovation system that hinder the effective networking of its components*" (EC, 2002).

Particularly important is here the organisational development in companies: the capacity (and not only the will) of companies to take on proactive environmental strategies is key to eco-innovation (Kemp, Andersen & Butter, 2004). Also the financial sector is central and the analysis of how environmental knowledge is transferred within and between national innovation systems.

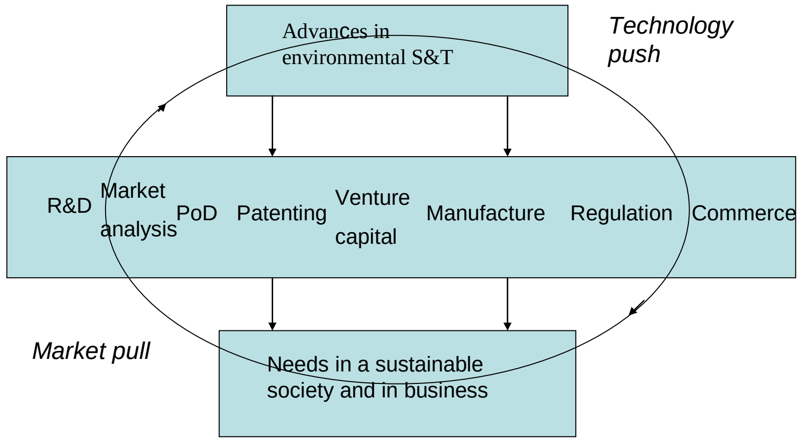

Figure 3: Eco-innovation indicators must measure the responses along the innovation chain, as a result of technology push and market pull (EEA adapted after Trott 2002)

LIDAR and other optical environmental measurement techniques

Innovation chain	Main applications: Environmental monitoring of air pollutants from diffuse sources. Three-dimensional mapping and pollutants fluxes.
Research	Sune Svanberg, Lund Laser Centre, 30 years of R&D in LIDAR, resulting in spin off applications. Support from national public research bodies, and EU's Fifth framework research programme.
Development	Mobile ground-based LIDAR system measuring air pollution concentration, and fluxes at industrial plants both for environmental, energy saving and safety concerns. DOAS (Differential Optical Absorption Spectroscopy) for urban surveillance of air pollutants
Market analysis	LIDAR in mercury research networks EMECAP www.emecap.com. Quantification of VOC and aromatic emissions www.spectrasyne.com. Monitoring of industrial plants such as refineries www.gasoptics.com. Spin off cancer diagnostics www.spectracure.com. DOAS spin off company from the LIDAR group www.opsis.se.
P&D	LIDAR prototype supported by public national R&D bodies.
Patenting.	No patents.
Venture capital	Statoil Innovation AS is a major shareholder of Gasoptics. Lund university is a shareholder through LUAB.
Regulations	Compliance with EU regulation and US EPA requirements are important for OPSIS. Several LIDAR systems in Europe, those in Eastern Europe probably subsidised.
Commerce	Establishment of LIDAR start-up company Lighten AB. OPSIS AB founded 1985 in Sweden with worldwide sales. GasOptics Sweden AB and Spectracure AB in Lund, Sweden. The British company Spectrasyne.

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Nitric oxide (NO) as a biomarker of airway inflammation

Innovation chain	Diagnostic and therapeutic instrument for asthma.
Research	NO as endogenous regulatory molecule and a messenger in biological processes. Detection of NO in exhaled air. Asthma patients with elevated levels of NO. Supported by national public research bodies.
Development	Mainly institutional support. No public funding.
Market analysis	Dialogue with the patent engineers also covering potential market. Research and monitoring of populations short-term market.
P&D	A first prototype of NIOX developed 1995.
Manufacturing	Karolinska Institute Innovation Centre: negotiations with small medical enterprises and big industries. Manufactured by Pharmacia Diagnostics.
Patenting.	Early patent application. Support by mentor and patent engineer. Now, patenting service at the university (Karolinska Institute).
Venture capital	Investments funds and University funds. 'Early money' from university. Karolinska Institute owns 3% of the shares.
Regulations	Important with compliance of the Medical Device Directive approving for clinical use in EEC countries, and FDA for clinical use in the US.
Commerce	Start up company at the Karolinska Institute. Today, Aerocrine AB has the intellectual property; and develops and commercialises the product. Hospitals and universities in US is today the main market. The company has 22 employees. http://www.aerocrine.com.

European Environment Agency

Figure 4: Innovation is also necessary in methods development in environmental monitoring and diagnostics. Two examples demonstrating links and obstacles along the innovation chain. Source EEA

Element 3. A Taxonomy of Eco-innovations

A range of typologies of eco-innovation (or rather environmental technologies) exists, often related to analyses on the environmental industry or cleaner technologies. The problem is that the definitions tend to be very diffuse and not clear-cut. The categorizations are often more rooted in the history of environmental policy than innovation dynamics. They tend to focus on the degree to which products contribute to environmental improvements (a normative approach) rather than how they function on the market.

Also, innovation should not only cover environmental technology but also identify, assess or solve environmental problems with other tools like market-based instruments or substitution. An operational taxonomy that entails key types of eco-innovations with respect to their different roles on a (greening) market is necessary.

In the Technology Action Plan of the EU Commission environmental technologies are defined as:
all technologies whose use is less environmentally harmful than relevant alternatives. They include technologies to manage pollution (e.g. air pollution control, waste management), less polluting and less resource-intensive products and services (e.g. fuel cells) and ways to manage resources more efficiently (e.g. water supply, energy-saving technologies). Other more environmentally-sound techniques are process-integrated technologies in all sectors and soil remediation techniques (EU Com, 2004).

Interpreting this somewhat fussy, broad statement, the ETAP states that eco-innovations are all technologies and services, which contribute to a better environment. Two categories can be identified:

- Pollution- and resource handling technologies and services.
- All technologies, products and services, which are more environmentally benign than their relevant alternatives.

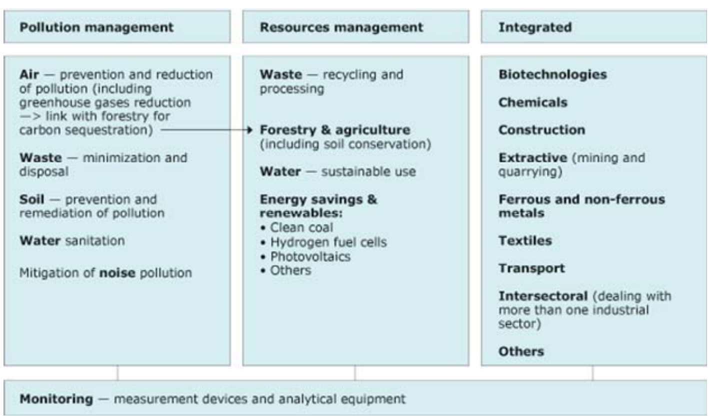


Figure 5: EEA Environment technologies portal www.technologies.ewindow.eu.org, an operational taxonomy of environmental technology.

This paper suggests that in considering the innovation conditions, this could be expanded into five categories of eco-innovations:

1. Add-on innovations (pollution- and resource handling technologies and services)
2. Integrated innovations (cleaner technological processes and cleaner products)
3. Eco-efficient technological system innovations (new technological paths)
4. Eco-efficient organizational system innovations (new organizational structures)
5. General purpose eco-efficient innovations

Source: Maj Munch Andersen, Risoe National Laboratory, 2005[3]

The first category is similar to the first one of ETAP, the others represent different forms of innovations which are more environmentally beneficial than relevant alternatives. They differ in the way the environmental dimension is constituted in the innovations; hence they are subject to very different innovation conditions such as risks, learning and transitions costs and market effects.

A very short explanation of the taxonomy is given here:

Ad. 1 Add-on innovations (pollution- and resource handling technologies and services)

This group is the most well-defined. These are products (artifacts or services) that improve the environmental performance of the customer. The product in itself need not be environmentally friendly.

They deal with environmental solutions at the sink side (the many technologies and services which clean up, dilute, recycle, measure, control and transport emissions) and the source side (extraction and supply of natural resources and energy). Nature conservation, influenced by both sink and source activities, should be included here. These technologies are developed by what is generally understood as the environmental industry.

These technologies typically have limited systemic effect as they seek to be added-on to existing production and consumption practices without influencing these significantly. Very radical add-on technologies could, however, have wider systemic effects but the incentives for developing such are small.

Ad. 2. Integrated innovations (cleaner technological processes and cleaner products)

These are innovations, which contribute to the solutions of environmental problems *within* the company or other organizations (public institutions, families..), in this sense they are integrated. They are the solutions which contribute to changing production and consumption practices in organizations, most importantly in companies.

The innovations enable energy and resource efficiency, enhance recycling or enable the substitutions of toxic materials. Typically, they make either the production process or the product more environmentally benign (cleaner). Hence,

[3] This taxonomy has not been published yet and must therefore not be used without permission from the author.

companies who have invested in integrated innovations (by buying and/or developing these) aim to appear more eco-efficient than similar competitors, either in the overall environmental performance of the company or in the environmental impact of the given product. They may, however, also have been introduced for other purposes, such as productivity aims. The innovations are often technical, but can also be organizational, i.e. changes in the organization of production and management. The "greenness" of these products is relative and may change over time.

Ad. 3. Eco-efficient technological system innovations (new technological or systems paths)
These are innovations that represent a technological discontinuity. They are not cleaner than similar products but rather offer very different solutions (a new technological trajectory) to existing solutions. These radical innovations have wide systematic effects; they built on new theories, competencies and practices and may demand a change of both production and consumption patterns. The environmental dimension lies in the production/product design alone, which is (supposedly) greener than the (dissimilar) alternative. The production methods itself need not be clean, and in some cases attract little attention. Examples are renewable energy technologies (as opposed to fossil fuel based technologies) and organic farming (as opposed to conventional farming).

Ad. 4. Eco-efficient organizational system innovations (new organizational structures)
These innovations entail new concepts for an eco-efficient way of organizing society. This means new ways of organizing our production and consumption at the system level, with new functional interplays between organizations, e.g. betwen companies ("industrial symbiosis"), between families and workplaces etc. ("Urban ecology"). These innovations imply changes in the regional and physical planning and technical infrastructure in varied ways. The innovations are mainly organizational and may be conceptually very radical but not necessarily technically radical. They emphasize the importance of the space dimension for eco-innovation. These innovations are to a large degree within the domain of public authorities, which need to cooperate with companies to develop the solutions.

Ad. 5 General purpose eco-efficient innovations
Certain technologies affect the economy profoundly as they lie behind and feed into a range of other technological innovations. Innovation researchers refer to how these technologies define the dominating techno-economic paradigm at any given time (Freeman and Louca 2001). Changes in the general purpose technologies are so fundamental that they will have major effect on eco-innovations and special attention should therefore be given to developments within these. The enabling (derived rather than direct) negative and positive effects technologies such as ICT, biotechnology, and lately nanotechnology may have on eco-innovations is in need of special scrutiny (see also Hertin and Berghout 2001, Andersen, 2005b).

3.2 The Innovation Policy and Indicator Terrain
Innovation policy basically builds on three elements:

- Innovation ‘dynamo’, key dynamic factors creating and shaping innovation in firms.
- Transfer factors: human, social and cultural factors influencing information transmission.
- Framework conditions: general conditions and institutions which set the range of opportunities for innovation.

Source: Oslo Manual, 1997

The Trend Chart Approach, which forms the analytical basis for the EU innovation policy, seeks to operationalize these by operating with three types of analyses:

1. European Innovation Scoreboard (EIS)
2. Sectoral Innovation Scoreboard (SIS)
3. National Innovation Systems (NIS)

The European Innovation Scoreboard[4] is an annual assessment of innovation performance in the individual Member States of the European Union. The scoreboard is a "benchmarking" tool comparing EU performance with the US and Japan. It is designed to stimulate debate between members of the business, research and policy-making communities as well as to provide a starting point for policy improvement and mutual learning. It operates very much with simple composite indicators, as illustrated below.

Summary Innovation Index – 1

Figure 2. The 2003 SII-1

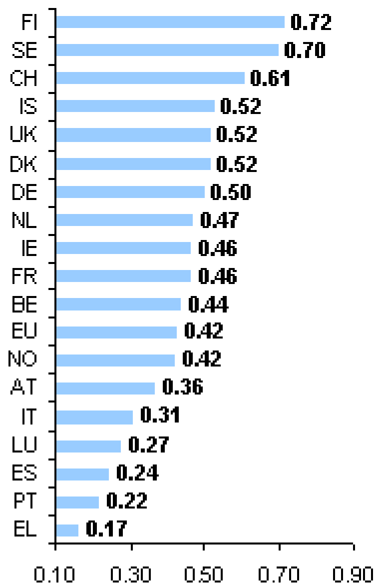
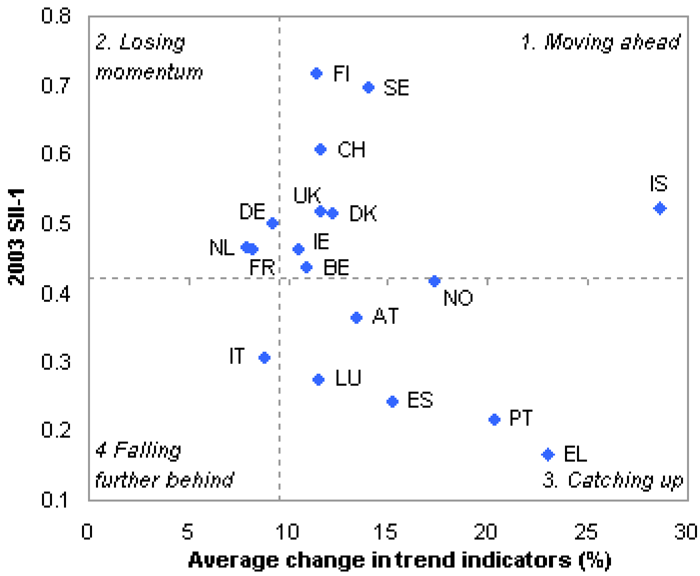


Figure 3. Overall country trend by SII-1



The figure shows the results for the 2003 SII-1. Finland and Sweden have by far the highest SII-1 and are confirmed as the European innovation leaders. Spain, Portugal and Greece show the weakest innovation performance.

Figure 6: The European Innovation Scoreboard

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[4] http://www.cordis.lu/innovation-smes/scoreboard/

The overall EIS analyses are supplemented by the SIS and NIS analyses.

The Sectoral Innovation Scoreboard (SIS) uses similar indicators than the EIS and allows for more precise international comparisons in the innovative capacity of different industrial sectors. This analytical tool will be one of the main inputs of the forthcoming Sectoral Innovation Watch (see section 4.1), which will try to understand the reasons behind differing innovation performance across different sectors.

The National Innovation System (NIS) analysis
The national innovation system (NIS) frame is none the least interesting because it forms the basis of much innovation and research policy (OECD, 1999, 2000, European Commission, 2002). Analyses of NIS Indicators in the European Trend Chart entail the following indicators:

Structural economic:
– Demand for innovations (4 indicators)
– Industry structure (3 indicators)
– Open economy (3 indicators)
Socio-cultural-institutional:
– Finance system (1 indicator)
– Receptiveness to new ideas (5 indicators)
– Social equity (3 indicators)
– Labour market (2 indicators)
– Entrepreneurial attitudes (2 indicators)
– Social capital (1 indicator for trust)

The NIS frame seeks to be comprehensive and both cover the innovation ‘dynamo’, the transfer factors and the framework conditions. The NIS studies based on these indicators seek to identify the specific characteristics of each national/regional innovation system in their way of innovating.

As yet the innovation scoreboard does not include environmental analyses in their innovation system analyses, but does include issues on social capital and social equity. The natural capital discussion is strangely absent.

It would be an obvious place to seek to integrate EI-indicators. The European Competitiveness Index[5] measures the competitiveness of Europe's nations and regions and also the Innovation Capacity Index (Porter and Stern) would be an interesting target for eco-innovation indicators.

3.3 What purposes should the EI-indicators fulfil? (selection criteria)

The delimitation of the frame should be governed by the purposes of the indicators wanted. It is suggested that the EI-indicators should fulfil three purposes, namely providing:

1. New policy signals
2. New incentives
3. New insights

[5] http://www.hugginsassociates.com/

Ad. 1. New policy signals
EI-indicators raise many new issues and perspective compared to traditional environmental policy, predominantly in linking competitiveness to environmental performance. Rather than aiming for specific urgent environmental goals the main question addressed is *how to achieve a high innovative capacity on eco-innovation.*

This includes sub-goals such as:
- Making eco-innovation the "easy innovation" in the EU innovation systems.
- Building strong green competencies and absorptive capacity.
- Making a high environmental performance a brand/trademark of EU countries (Andersen, 2004b, Kemp and Andersen, 2004).

For policy reasons the national and regional level is important, emphasizing international benchmarking within EU countries as well as between EU and e.g. US and Japan/East Asia. The signalling effect is strengthened if EI-indicators are integrated into innovation statistics and indicator work, and not only in the environmental statistics/indicator work.

Ad. 2. New incentives
EI-indicators reflect the environmental performance of specific agents (individuals, companies and other organisations and nations/regions, whereas most environmental indicators measure the overall status of the environment. Potentially, EI-indicators could provide strong incentives for environmental action (there is a considerable unused potential here), which is important to consider when selecting indicators.

Ad .3. New insights
The eco-innovation indicators can contribute to new types of empirical investigations of eco-innovation dynamics and analyses (national or EU level) of environmental innovation systems. This could provide new insights into the specific characteristics and conditions of different national innovation systems within the EU as well as discussing the connectivity of the EU (i.e. to which degree the EU can be seen as a distinct innovation system with regard to environmental innovation) and highlight conditions for the transfer of best policy practices for eco-innovation between the EU countries, e.g. towards the member states. As yet the NIS perspective has only to a very limited degree entered environmental policy making and analysis (see Andersen, 2004a, 2004b, Hübner and Nill, 2001, Kemp and Rotmans (2001), Kemp, R. (2002), Foxon 2003, Weber and Hemmelskamp (eds.) forthcoming, Kemp and Andersen, 2004). The closest empirical analysis is one superficial international analysis (Rand Europe, 2000) concentrating on structural feautures and policy regimes and one national study showing development over time (Hübner et al. 2000).We lack as yet to see the first thorough international empirical environmental NIS analysis being made. Such analyses are, however, hampered by the lack of data.

Currently we know very little about the greening of national innovation systems and the international distribution of innovative capacity on eco-innovation. Needless to say the strong role of the hitherto primarily national public intervention on environmental issues means that there are considerable differences in the national environmental innovation systems.

Issues which analyses based on EI-indicators could address are:

- Who are the green leaders when it comes to different regions and nations and how big are the differences? How is the eco-innovative capacity of the EU as opposed to other interesting regions, e.g. US, Japan, India and China?
- Who are the green leaders when it comes to industrial sectors and types of companies and how uneven is the greening of the market?
- The development (greening) over time. How is the rate of improvement now as opposed to earlier?
- How do the national environmental innovation systems within the EU differ when it comes to patterns in eco-innovative activities and the supporting institutional set-up? How are the conditions in the new member states?
- Can we identify the contours of key competencies and knowledge clusters within the EU, which may form the basis for a high innovative capacity and competitiveness on environmental innovations in the future?
- How does the rapid globalization influence on the global distribution of eco-innovative capacity?
- What is the relationship between competitiveness and environmental performance?
- How does the institutional set-up effect eco-innovation? What characterizes innovation friendly environmental policy styles?

These are analyses that haven't really been made so far and which have both implications for environmental as well as innovation policy. They could renew the debate on environmental issues and gain new political interest, none the least among the more economic policy domains. They are vital for creating greater synergy between innovation policy and environmental policy.

As it is now we know nothing about who is in the green lead, (we presume that those with advanced environmental policies are), changes in the national and international organization of green knowledge production or the dynamics of the greening of industry and innovation systems.

Hard core (none-green) innovation researchers tend to have a narrow focus on competitiveness and have only to a very limited degree dealt with sustainability issues. The historic dichotomy between competitiveness and environmental issues still persists and is embodied not only on the market but also in policy regimes - and indicators (Andersen 2004).

Below first some key issues on EI-indicator work are summarized. Then different analyses and data sources relevant to eco-innovation are run through, starting with the more well-established environmental industry and eco-efficiency analyses moving on to more hard core but also explorative innovation analyses, finally touching upon innovation system analysis.

4. Existing main methods and experiences of analysing eco-innovation

Focus in this section is on the three of the hitherto most used approaches related to eco-innovation, studies on the environmental industry, eco-efficiency as well as analysis of the environmental performance of industrial sectors. These three themes share a strong focus on firm and/or the sector level (though not exclusively) and are thus complementary in many respects.

4.1 The environmental industry

Some of the best existing data and also earliest conceptual clarification related to eco-innovation is the work on the environmental industry. The environmental industry is broadly defined by Eurostat/OECD as:*"The environmental goods and services industry produce goods and services to measure, prevent, limit, minimise or correct environmental damage to water, air, and soil as well as problems related to waste, noise and eco-systems.* This includes cleaner technologies, products and services which reduce environmental risk and minimise pollution and resource use*"*(Eurostat/OECD 1999).
In statistical practice the analyses focus on measuring those industries producing goods and services related to:

- Remedy or measure/diagnose environmental problems (emissions, recycling, noise, eco-systems)
- Natural resource extraction (water supply, metals, minerals)
- Selected green products

Increasingly, the environmental industry includes the expanding environmental service sector. Often works on the environmental industry include a few typical examples of green products such as renewable energy technologies or recycled paper. Explanations of these choices and clear delimitations are often weak though, and it is well recognized that the environmental industry statistics only gives a partial picture of eco-innovation.

Earlier (ten years ago) there was quite a lot of work going on in developing statistics on the environmental industry. Eurostat undertook a joint project with OECD to develop a handbook including definitions on the subject of environmental industry. This work was finalized in 1999 with the publication "The Environmental Goods & Services Industry: manual for data collection and analysis", see the above definition; since then most of the work has stopped. Generally, the statistics on the environmental industry focus on the economic structure in this area while the linkage to innovation is weak. It is possible to extract information about import/export of certain environmental protective products from a database at Eurostat (COMEXT).

There is ongoing work at OECD at DSTI on the measurement and classification of the "environmental goods and services sector". DG ENV has initiated more recent empirical studies, the Esto (2000) by JRC and Ecotec (2002). There is also an excellent American study from 1998 (X). DG ENV are currently working on the follow-up of the 2002 ECOTEC study together with Ernst & Young, expected finished in the autumn 2005.

An upcoming interesting analysis is the SYSTEMATIC proposal selected for funding under a recent FP6 call, which will be launched as the Sectoral Innovation Watch. . SYSTEMATIC will take it to analyze innovation performance in 10 industrial sectors across EU-25 Member States. One of the chosen sectors is the “eco- industries”. The contractors have been asked to stick to the definition of eco-industries proposed by Eurostat/OECD..The interesting thing about this analysis is that it goes beyond mere statistical market analysis to incorporate a comprehensive qualitative analysis of innovation dynamics and related policies. This includes e.g. analysis of market dynamics and market openness, looking into innovation chain dynamics, skilled force availability, identifying innovation champions (companies), carrying out cluster analysis and identifying international pioneers. Innovation Panels will be established for 6 industrial sectors and two horizontal topics, namely eco-innovation and high-growth SMEs (gazelles). The Panels (10-12 people) will be populated mainly with industry experts, but also academics and policy makers, and will validate analytical findings and flavour policy recommendations with hands-on experience from the sectors. The Sectoral Innovation Watch and the panels will be launched in late October 2005, with a duration of 30 months..

The SYSTEMATIC project is likely to provide new insights and methodological clarifications that could be helpful in developing EI-indicators, since these kinds of analyses have not really been carried out before on the environmental industry.

It is important that the considerable methodological work undertaken in the region of analyzing the environmental industry is utilized in developing EI-indicators.

4.2 Eco-efficiency

Concerning innovation output a core theme is to discuss how eco-efficiency indicators can be used to illustrate and benchmark the innovative capacity of industrial sectors, nations and regions (e.g. EU versus North America or East Asia).

Eco-efficiency is a management philosophy to guide and measure companies and other actors development in environmental performance. Eco-efficiency measures the value from a product or service against the environmental impact. It is a dynamic concept aiming at gaining more value with less environmental impact thereby combining environmental and economic gains. The underlying idea of eco-efficiency is de-linking growth and environmental pressure (WBCSD 2000).

Box 1. Eco-efficiency

Eco-efficiency measures the improvements of or the degradation in the environmental impact for a given activity.

$$\textit{Eco-efficiency} = \frac{\textbf{\textit{product or service value}}}{\textbf{\textit{environmental impact}}}$$

The environmental impact is measured as both resource use (the source side) as well as emissions to air, soil and water (the sink side) per produced unit/activity. Amounts as well as toxicity is important.

The term eco-efficiency is often understood as measuring the environmental performance of single plants, but there is no reason why the concept should be restricted to this category.
It is here understood as a comprehensive notion that may be applied to various levels of analysis, e.g. the single company, the industrial sectors, the family, the region or the entire economy. The WBCSD has identified seven elements to improve eco-efficiency[6]:

- Reduce material intensity
- Reduce energy intensity
- Reduce dispersion of toxic substances
- Enhance recyclability
- Maximize use of renewables
- Extend product durability

Eco-efficiency analyses measure the progress in environmental behaviour of different agents. This progress may reflect the degree of eco-innovation or structural changes (changes in production or consumption patterns). As such they do make up a measure of innovation output.[7]

The advantage of eco-efficiency analyses is that they can capture the relativity of greenness, i.e. compare progress in integrated technologies, and thereby handle the moving target of greening. However, hitherto, eco-efficiency analyses have primarily been used to analyze the decoupling of environmental impact from economic growth at the macro level rather than developments in innovation capacity. E.g. in 1994, the members of the Factor 10 Club adopted the Carnoules Declaration in which they argue for a ten-fold increase in resource productivity (Bleischwitz et al. 2003).

Eco-efficiency makes up a practical concept that seeks to make sustainability operational for business processes. Eco-efficiency, in this respect, provides hands-on tools, which are compatible with the functions and practices of business and, at the same time, responding to the goals of the policy makers at the macro level. Moreover, it is a powerful concept in requiring consideration of multi-level aspects and further a focus on the most relevant ones in accordance with the regional or local (social, environmental or economic) priorities (Bleischwitz et al. 2003).

International comparisons of eco-efficiency performance are especially interesting at the detailed sectoral (branch) level, which allow for internationally comparable analysis of environmental progress. At the national level the eco-efficiency analysis more reflect structural differences of the economy, i.e. the degree of environmentally heavy industries, than developments in environmental

[6] World Business Council for Sustainable Development (2000): Eco-efficiency – creating more value with less impact.
[7] Ecoefficiency strategies assist in implementing and integrating economic and social risk minimisation for companies, industries, economic areas and households. Eco-efficiency can be achieved by the delivery of competitively priced goods and services that satisfy human needs and bring quality of life, while progressively reducing ecological impacts and energy and resource intensity throughout the life cycle, to a level at least in line with the earth's estimated carrying capacity (WBCSD 2000).

performance. This does not mean that such analyses are uninteresting, on the contrary since the economic and social structures have a heavy influence on the production and consumption patterns. These analyses say a lot about the environmental impact of different nations and the character of the environmental innovation systems. But they say little about who is in the green lead. It could be interesting to seek to carry out national eco-efficiency analyses, which seek to normalize the structural differences in order to benchmark progress in eco-innovative activities and the eco-innovative capacity of nations/regions.

At the company level and conceptually the WBCSD has been a key actor advancing eco-efficiency as a management philosophy, and lately also sector level analyses (WBCSD 2000). Also the Wuppertal Institute and the EEA have done extensive work on eco-efficiency. Related to this is also extensive work on material flows and resource efficiency made by the EU Waste Topic Centre (ETC-WMF*)*. A related Wuppertal project, which aims at encouraging eco-innovations in small and medium-sized enterprises, is the Efficient Entrepreneur Calendar[8] and "Factor X Technologies" project. The calendar guides businesses through a programme that simultaneously saves money, increases efficiency, and reduces environmental impacts. The calendar helps to collect relevant data among suppliers and is a basis for internal & external communication in the supply chain. The Factor X Technology methodology developed assists systematic implementation of recent environmental technologies on the company level. A screening methodology helps the company to identify those products and applications that are most eligible for Factor X improvements.

Eurostat has also done some work earlier, which could be updated, but there are no regular analyses.

Data problems remain, at the national level because of limitations in internationally comparative data. At the sectoral level because of lacking long time series or limited company/sector details on many environmental data; energy data are among the best. For each sector there is considerable work in finding the relevant parameters and data and appropriate aggregation levels.

4.3 Sector/enterprise analyses and databases

Perform/MEPI: It needs to be considered whether the UK PERFORM sectoral environmental database could become a model for providing further data at the industrial sector level. PERFORM has been created at SPRU and builds on the MEPI project of JRC. The project stopped last year. It is based on voluntary data provided by UK companies as well as available statistics.
COMPASS: The COMPAnies' and Sectors' path to Sustainability (COMPASS) [9] project made by the Wuppertal Institute enables decision-makers at the company and sector level to provide transparent information to external stakeholders about their performance and to obtain an internal information basis on economic, social and environmental aspects for evaluating and continuously improving sustainability performance. The main objectives of COMPASS are to:

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[8] http://www.efficient-entrepreneur.net . In 2005 the programme has been extended to the SMART Entrepreneur. It guides business now through all sustainability pillars (www.smart-business.bz). The toolbox will be available in 2006.
[9] Information on the COMPASS project is available at the website http://www.sustainability-compass.net/

- help companies/sectors to translate the broad concept of sustainability into specific and measurable targets and indicators useful in day-to-day business decisions;
- pro-actively involve internal and external stakeholders in order to bring in new knowledge to the company and sector level associations, and access to new perspective on innovation.
- enable decision-makers to optimize processes, products and services throughout the entire value chain considering economic, ecological and social aspects (Kuhndt and Liedtke 1999; Kuhndt et. al. 2002).

A sector level application of COMPASS was done on behalf of the GDA (Gesamtverband der Aluminiumindustrie) and the European Aluminium Association (EAA). This project aimed at defining sustainability issues in the aluminium sector within the context of the European and the international debate and developed core sustainability indicators for the European Aluminium Industry (EAI) and measured the innovation capacity in the sector. (Kuhndt, et al., 2002).

Env. Indicators Bank, Agrobig (LEIA
EPER: It needs to be considered how the EPER database on environmental performance of industry can be utilized as a data source for eco-innovation/eco-efficiency analysis particular at the industry level.

Overall: Using eco-efficiency analysis as a proxy for eco-innovative activity entails not a redefinition but a reinterpretation and use of the eco-efficiency term seen in relation to how the concept is normally understood and used. Still, despite some data problems there is thorough methodological work to build on.

5. Innovation data sources

This section deals with the central data sources of hardcore innovative activities, patents and R&D investments, data sources that have so far only been little applied to eco-innovation analyses, as well as some data sources t support these. They measure innovation output (less so competence level and market penetration):

5.1 Patents

Little work has been done so far on patent analysis related to eco-innovation. The OECD is currently undertaking a study on this related to the project on "Environmental Policy and Technological Change: Empirical Analysis and Public Policy Implications", drawing up links between environmental policy and technological innovation.

As proposed work for 2005-2006 the Economic Analysis and Statistics Division of the OECD's Directorate for Science, Technology and Industry (DSTI) has initiated a project on patents, including the development of a harmonised patent database, bringing together patent files from North America, Europe and Japan. Preparation of the database has recently been completed, and the data is now available to be used for a wide variety of empirical analyses. The database is unique, allowing for empirical analysis of innovation trends across a wide crosssection of the OECD, with time-series stretching back twenty years for at least some countries.[10]

Amongst other areas, the project is to provide insight into the identification of environmentally-preferable technologies using patent data. This requires careful attention since, while some patent classes involve clearly identifiable 'environmental technologies'[11], in other cases environmentally-beneficial innovations involve more far-reaching changes in production processes.[12] Thus, care needs to be taken in the choice of technologies to be examined in the empirical phase of the project. For the purposes of this project, it is not envisioned that it would be fruitful to provide an over-arching definition of "environmental" technologies per se, but rather to identify specific areas in which innovations have resulted in unambiguous environmental improvements.[13]

The cross-sectional nature of the data (drawing upon patent regimes in three regions), may allow for some elaboration of these methodologies.
Patent files are a particularly rich source of data on innovation since they provide a great deal of concrete information which can be applied in policy studies in a wide variety of areas. Moreover, DSTI is in the process of linking patents data (which uses the international patents classification) with other data (i.e. international sectoral classifications) which could be used to examine the links between public policy and technological change.[14]

The work entails:
- Developing a methodology for the identification of environmentally-benign innovations (most likely for a small number of polluting or resource-intensive sectors) and linking these with patent data;
- Assessing the empirical links between different public environmental policy regimes and 'environmentally-friendly' innovation and diffusion in the specific areas chosen; and,
- Assessing the nature of effective and efficient co-ordination between environmental policy and innovation policy in encouraging environmentally-preferable technological change.

5.2 Environmental R&D

Eurostat has some somewhat patchy data on environmental R&D. It is an area that so far has received little attention in Eurostat. The data on environmental protection expenditure can be used to show how much is spent on processes and equipment that prevent or reduce pollution, but we do not know if these equipments are new on the market or old standardized ones. Statistics on expenditures for environmental R&D are readily available on the national level in the NewCronos (NC) database. These data relate to expenditures related to environmental regulation only.

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[10] See http://www.oecd.org/document/10/0,2340,en_2649_34451_1901066_1_1_1_1,00.html
[11] For instance, there is a specific class (423/242-244 and 423/569-570) for equipment for the control of sulphur compounds in the US patent data.
[12] For instance, the development of advanced fuel mixing technologies to reduce sulphur emissions would be one such example.
[13] This is the subject of on-going work at DSTI, in the context of the measurement and classification of the "environmental goods and services sector".
[14] See http://www.oecd.org/document/10/0,2340,en_2649_34451_1901066_1_1_1_1,00.html

However, expenditures and investments in environmental R&D at the industry level are only available in some countries and cannot be retrieved from NC. These data could show the actual expenditures invested by private companies on R&D for environmental purposes would be visible. But as of yet these data are included in the aggregate form of “other”. The data do not only relate to regulation but also to initiatives of their own. However, R&D in product development is not included unless they are due to regulations. R&D in production development is the main receiver.

The indictor on R&D is aggregated with other environmental domains such as radiation and activities that cannot be classified elsewhere, so the indicator is not "pure". Data exist for national expenditures as well as for certain sectors.

In the OECD a large international survey has been carried out. Central information in this survey is information on environment-related research and development (see further below).

5.3 Surveys

Innovation statistics rely quite heavily on innovation surveys to provide more detailed and sectoral data on innovation performance. It needs to be investigated whether existing or new international surveys and/or related databases can and should become a data source for eco-innovation indicators.

<u>CIS:</u> is an innovation survey in EU, mandatory since 2004, taking place every two year, which feeds into the European Innovation Scoreboard (EIS).. It is possible to pay for additional questions, but the trend goes towards less not more questions. There have been a few environmental questions in CIS; in 2004 one question has been included (section 7.1 of the questionnaire) as to the effect of innovation: “Improved environment, health and/or security relation”. So far, the environmental data from CIS have not been used very much.

A CIS survey is undergoing now. Possibly new environmental questions could be added for the next survey in 2007, but data will not be available before 2010. OECD (the Environment Directorate on ‘Environmental Policy Design and Firm-level Management’ (see ENV/WPNEP(2003)13), has recently undertaken a large survey on environment-related research and development, colleting data from approximately more than 4,100 firms in seven OECD countries. The survey covers a range of issues related to eco-innovation, also R &D as stated and firms’ likelihood of adopting changes in production process rather than end-of-pipe technologies.

6. The greening of actors/institutions in the innovation system

Taking on an innovation system perspective, the following issues could be included:

- Organisational development (companies): CSR/EMS data, environmental accounting/triple bottom line
- Eco-Entrepreneurship: the role of green upstarts for eco-innovation
- The financial sector
- Knowledge institutions and education
- Policy/institutional set up: innovation friendly environmental policy styles

Organisational development: Firm environmental capabilities and proactive CSR strategies are key issues for eco-innovation. Fairly good international data, but limited large/international analysis on the greening of (different types of) enterprises and sectors.

Entrepreneurship:
The upcoming Eurostat study on the Environmental industry will make specific interviews with businesses and could possibly contribute to connecting entrepreneurship and innovation output.
Data on eco-entrepreneurship: [?]

Financial sector:
Data sources: Occasional reports on environmental strategies and investment activities rather than statistics. Statistics on venture capital is not linked to technology areas.

Knowledge flows:
Data sources: Input-output data, market shares/trade of lead eco-products & environmental technologies, labour & student mobility…,

Knowledge institutions and education:
Data sources: there are some national data on the research activities in different research areas, e.g. research in "environment" and "energy" documented in Denmark, but no data collected at the EU level, see also R&D section for the funding data.
Data on education: [?]

Policy:
Comparative survey of policy regimes and effects.

Possibly, a review of relevant environmental composite indicators could aid this theme, going through:

Environmental Sustainability Index (Yale & Columbia University), which we co-authored
Ecosystem Wellbeing index (Prescott-Allen)
Eco-Indicator 99 (Pre Consultants, the Netherlands)
Environmental Performance Index for Rich Nations (Birdsall and Roodman)
Environmental Policy Performance Index (Adriaanse A.)
Index of Environmental Friendliness (Puolamaa et al., Finland)
Index of Environmental Indicators (Fraser Institute)
Bertelsmann Transformation Index (Bertelsmann Foundation)

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Appendix 1 Input from Eurostat for the EEA Workshop September 29 2005

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Innovation chain	**Preferred variables**	**Main innovation category**	**Existing statistics at Eurostat**
Research	Public research funds in environmental research, or in absence of eco-definition selected scientific disciplines, mainly applied research Exploring the EUROSTAT and OECD statistics Number of citations or doctoral theses	Services	Public research investment: we have data on Government Budget Appropriations or Outlays on R & D, broken down also into amounts dedicated for environment (chapter 3: Control and care of the environment). New data on 2003 and 2004 will be available very soon. Otherwise we have data on R & D expenditure broken down by Nace, Citation statistics: we are not doing this, some ad-hoc work is done by DG RTD without continuity
Development Prototype/ demonstration	Public development funds Industrial development investments	Product	Government budget and outlays on R&D, environment domain (NABS)
Patenting	Number of patents in selected areas EPO or OECD	Product	Patent statistics: here we are more flexible and can aggregations of the IPC codes if we have a list of relevant codes for eco-innovation output
Venture capital	Number of companies or turnover of venture capital	Products/services	Venture capital: we are currently producing data on the venture capital funds raised at early stage and advanced stage as two distinct totals, but there is no link to (eco) innovation
Environmental regulations	Environmental subsidies Technology transfer support	Products /services	COFGO data on environmental subsidies from general government
Manufacturing	Eco-industries Investments	Products Type of technology	Some products related to environmental technology can be found in trade statistics – imports/exports SBS Regulation will include variables on product turnover –CPA classification, core industries can be distinguished. Available data for the manufacturing industry include also how much they are spending on new technology and if it is treating or preventing environmental pollution
Environmental consultancy	Number or turnover of environmental consultancy	Products/services	Estimates might be possible in the short term. Eurostat is taking up the work of collecting data on “eco-industries” where environmental consultancy is a part in the winter 2005.

- There are also possibilities to produce eco-efficiency indicators such as emissions per value added or emissions per production on total economy and/or NACE classifications for further analysis. These measures are already in use, but have so far not been used to measure innovation.
- An idea is to link the CIS's questions on environment by NACE with other data such as environmental investments or emissions that is also disaggregated by NACE. This might explain in some degree how the sector looks like and how it acts. This could be used in turn together with regulatory data such as taxes and subsidies in these sectors for a broader view.

See also Eurostat's Statistics in Focus publications ..
http://epp.eurostat.cec.eu.int/portal/page?_pageid=0,1136250,0_45572552&_dad=portal&_schema=PORTAL

Appendix 2

Indicators of eco-innovation and environmental technologies used within composite indicators

Summary for the EEA Workshop September 29 2005

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A large number of composite indicators are regularly published by many intergovernmental, international and national institutions. Some of these composite indicators are built on sets of indicators, some of which are relevant to eco-innovation and environmental technologies. The present discussion will sketch upon the main features of 7 composite indicators, whose sub-indicators could provide a starting point for consideration with a view compile the EEA "Eco-innovation Indicators" list.

Environmental Sustainability Index (Esty *et. al*, 2005) is published by the Yale and Columbia Universities in collaboration with the World Economic Forum and the JRC. It benchmarks the ability of 146 nations to protect the environment over the next several decades. It does so by integrating 76 data sets – tracking natural resource endowments, past and present pollution levels, environmental management efforts, and the capacity of a society to improve its environmental performance – into 21 indicators of environmental sustainability. These indicators permit comparison across a range of issues that fall into the following five broad categories: Environmental Systems, Reducing Environmental Stresses, Reducing Human Vulnerability to Environmental Stresses, Societal and Institutional Capacity to Respond to Environmental Challenges, and Global Stewardship. The indicators and variables on which they are constructed build on the well-established “Pressure-State-Response” environmental policy model. The issues incorporated and variables used were chosen through an extensive review of the environmental literature, assessment of available data, rigorous analysis, and broad-based consultation with policymakers, scientists, and indicator experts.

Ecosystem Wellbeing index (Prescott-Allen, 2001) combines 51 indicators of land, biodiversity, water quality and supply, air quality and global atmosphere, and energy and resource use pressures into an index.

Eco-Indicator 99 (Goedkoop and Spriensma, 2001) is a damage oriented impact assessment method for materials and processes, which addresses three damage categories: (a) human health, (b) ecosystem quality and (c) resources, minerals and fossil fuels. The indicators are normalized using distances from european reference values, which are used as goalposts.

Environmental Performance Index for Rich Nations (Roodman, 2004) is a sub-component of the Commitment to Development Index. It is based on three components: depletion of shared commons (climate change, ozone depletion, and marine fisheries), international governmental cooperation (participation in multilateral environmental institutions, and contributions to such institutions), and contributions to international efforts to develop new energy technologies (renewable energy R&D, and deployment of renewable technologies). It covers 21 OECD nations.

Environmental Policy Performance Index (Adriaanse A., 1993) groups 42 indicators with a view to monitor the trend in the total environmental pressure in the Netherlands and indicate whether the environmental policy is heading in the right direction or not. The indicators are normalized using sustainability levels and policy targets as goalposts.

Index of Environmental Friendliness (Puolamaa et al., 1996) aims to provide diversified quantified information for environmental decision-making and discussion in Finland. Eleven indicators are included measuring greenhouse effect, ozone depletion, acidification of soil and water, eutrophication, ecotoxicological effect, resource depletion, photo-oxidation, biodiversity, radiation and noise. The indicators are normalized using national total pressures as goalposts.

Innovation Capacity Index (Porter and Stern, 2003) creates a quantitative benchmark of national innovative capacity, which highlights the resource commitments and policy choices that most affect innovative output in the long run. It is composed of five subindexes. The five subindexes are (1) the science and engineering manpower subindex; (2) the innovation policy subindex; (3) the cluster innovation environment subindex; (4) the innovation linkages subindex and (5) the company innovation orientation subindex.

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